

AMENDMENTS TO THE CLAIMS:

Please amend the claims, as indicated below. This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently Amended) A digital watermark embedding apparatus including a processor, the digital watermark embedding apparatus comprising:
 - an acquisition unit ~~configured~~ including input terminals to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;
 - a function generation unit coupled to the acquisition unit, the function generation unit being configured to generate a topological function corresponding to the topological invariant;
 - a ~~randomizing function generation~~ function randomization unit coupled to the function generation unit, the function randomization unit being configured to generate, based on the key information, a randomizing function ~~by mapping from a first space to a second space, map each block of the target content to a target space based on the randomizing function, the target space comprising embedding amounts, and compute a composite function by composition of~~ based on the randomizing function and the topological function, ~~the first space and the second space including a target space concerning embedding amounts; and~~

a function-embedding unit coupled to the function randomization unit, the function-embedding unit being configured to embed the digital watermark information in the target content based on the composite function in the target content,

wherein the ~~randomizing function generation unit generates the randomizing function and computes the composite function to obtain the embedded target content [[being]] is restored to the target content even if the target content with embedded digital watermark information is subjected to geometrical distortion after the composite function is embedded in the target content.~~

2. (Previously Presented) The digital watermark embedding apparatus according to claim 1, wherein the topological function includes a mapping from a base space concerning positions in the target content to the target space concerning embedding amounts, the mapping being based on the topological invariant.

3. (Original) The digital watermark embedding apparatus according to claim 2, wherein:

the target content includes one of still image data and moving picture data;
the base space is defined by pixel positions corresponding to the target content; and

the target space is included in a topological space corresponding to a set of assignments of values to pixels composing the target content.

4. (Original) The digital watermark embedding apparatus according to claim 1, wherein the function generation unit generates topological function values which express the topological function.
5. (Currently Amended) The digital watermark embedding apparatus according to claim 4, wherein the ~~randomizing-function-generation~~ function randomization unit generates composite function values by applying the randomizing function to the topological function values, the composite function values expressing the composite function.
6. (Original) The digital watermark embedding apparatus according to claim 5, wherein each of the topological function values and the composite function values indicate embedding amounts corresponding to positions in the target content.
7. (Currently Amended) The digital watermark embedding apparatus according to claim 5, wherein the ~~randomizing-function-generation~~ function randomization unit randomizes the topological function values using a block cipher based on the key information to generate the composite function values.
8. (Original) The digital watermark embedding apparatus according to claim 5, wherein the function-embedding unit embeds the topological invariant by varying the target content based on the composite function values.

9. (Original) The digital watermark embedding apparatus according to claim 1, wherein the function generation unit generates the topological function corresponding to the topological invariant which includes a homotopy invariant.
10. (Currently Amended) A digital watermark detection apparatus including a processor, the digital watermark embedding apparatus comprising:
- an acquisition unit ~~configured~~ including input terminals to acquire key information corresponding to digital watermark information, and a target content in which the digital watermark information is embedded;
 - a function detection unit coupled to the acquisition unit, the function detection unit being configured to detect a function embedded in the target content;
 - ~~an ordering-function-generation~~ a function ordering unit coupled to the function detection unit, the function ordering unit being configured to generate, based on the key information, an ordering function by mapping, map each block of the acquired target content with embedded digital watermark information ~~from a first randomized space to a second randomized space comprising embedding amounts~~, and compute a composite function ~~by composition of based on~~ the ordering function and the embedded function, ~~the first randomized space and the second randomized space including a target space concerning embedding amounts; and~~

a topological invariant computation unit coupled to the function ordering unit, the topological invariant computation unit being configured to compute a topological invariant based on the composite function, ~~[[and]]~~ the topological invariant serving as digital watermark information,

wherein the ~~ordering-function-generation~~ function ordering unit generates ~~the ordering function and computes the composite function to obtain an~~ restores the embedded target content ~~being restored to~~ ~~[[an]]~~ original target content even if the embedded target content ~~[[is]]~~ was subjected to geometrical distortion ~~after the digital watermark information is embedded in the target content.~~

11. (Previously Presented) The digital watermark detection apparatus according to claim 10, wherein the composite function includes a mapping from a base space concerning positions in the target content to the target space concerning embedding amounts, the mapping being based on the topological invariant.

12. (Original) The digital watermark detection apparatus according to claim 11, wherein:

the target content includes one of still image data or moving picture data;
the base space is defined by pixel positions corresponding to the target content; and

the target space is included in a topological space corresponding to a set of assignments of values to pixels composing the target content.

13. (Previously Presented) The digital watermark detection apparatus according to claim 10, wherein the function detection unit detects function values which express the embedded function.
14. (Currently Amended) The digital watermark detection apparatus according to claim 13, wherein the ~~ordering-function-generation~~ function ordering unit generates composite function values by applying the ordering function to the function values, the composite function values expressing the composite function.
15. (Previously Presented) The digital watermark detection apparatus according to claim 14, wherein each of the function values and the composite function values indicate embedding amounts corresponding to positions in the target content.
16. (Previously Presented) The digital watermark detection apparatus according to claim 14, wherein the order-function generation unit orders the function values using a block cipher based on the key information to generate the composite function values.
17. (Original) The digital watermark detection apparatus according to claim 14, wherein:

the composite function includes a mapping from a base space concerning
positions in the target content to a target space concerning

embedding amounts, the mapping being based on the topological invariant, the composite function including a parameter which is related to the topological invariant and determines the mapping; and

the topological invariant computation unit computes the topological invariant by acquiring the parameter based on the composite function values.

18. (Original) The digital watermark detection apparatus according to claim 10, wherein the topological invariant computation unit computes the topological invariant which includes a homotopy invariant.

19. (Currently Amended) A digital watermark embedding method comprising:
acquiring a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;
generating a topological function corresponding to the topological invariant;
generating, based on the key information, a randomizing function by ~~mapping from a first space to a second space, the first space and the second space including a target space concerning embedding amounts;~~

mapping each block of the target content to a target space based on the
randomizing function, the target space comprising embedding
amounts;

computing a composite function ~~by composition of~~ based on the
randomizing function and the topological function; and
embedding the digital watermark information in the target content based
on the composite function in the target content,

wherein ~~generating the randomizing function and computing the~~
~~composite function obtain the embedded target content~~ [[being]] is
~~restored to the target content even if the target content with~~
embedded digital watermark information is subjected to geometrical
distortion ~~after the composite function is embedded in the target~~
~~content.~~

20. (Currently Amended) A digital watermark detection method comprising:

acquiring key information corresponding to digital watermark information,
and a target content in which the digital watermark information is
embedded;

detecting a function embedded in the target content;

generating, based on the key information, an ordering function ~~by mapping~~
~~from a first randomized space to a second randomized space, the~~
~~first randomized space and the second randomized space including~~
~~a target space concerning embedding amounts;~~

mapping each block of the acquired target content with embedded digital watermark information to a randomized space comprising embedding amounts;

computing a composite function ~~by composition of~~ based on the ordering function and the embedded function; and

computing a topological invariant based on the composite function, ~~[[and]]~~ the topological invariant serving as digital watermark information,

wherein ~~generating the ordering function and computing the composite function obtain an~~ the embedded target content ~~[[being]]~~ is restored to ~~[[an]]~~ original target content even if the embedded target content ~~[[is]]~~ was subjected to geometrical distortion ~~after the digital watermark information is embedded in the target content.~~

21. (Currently Amended) A ~~computer-readable~~ computer-readable storage medium storing a program for enabling a computer to function as a digital watermark embedding apparatus according to a method, the method comprising:

instructing the computer to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;

instructing the computer to generate a topological function corresponding to the topological invariant;

instructing the computer to generate, based on the key information, a randomizing function ~~by mapping from a first space to a second~~

~~space, the first space and the second space including a target
space concerning embedding amounts;~~

instructing the computer to map each block of the target content to a
target space based on the randomizing function, the target space
comprising embedding amounts;

instructing the computer to compute a composite function ~~by composition~~
of based on the randomizing function and the topological function;
and

instructing the computer to embed the digital watermark information in the
target content based on the composite function ~~in the target~~
~~content,~~

wherein the ~~randomizing function is generated and the composite function~~
~~is computed to obtain the embedded target content~~ [[being]] is
~~restored to the target content~~ even if the target content with
embedded digital watermark information is subjected to geometrical
distortion ~~after the composite function is embedded in the target~~
~~content.~~

22. (Currently Amended) A ~~computer-readable~~ computer-readable storage medium
storing a program for enabling a computer to function as a digital watermark
detection apparatus according to a method, the method comprising:

instructing the computer to acquire key information corresponding to
digital watermark information, and a target content in which the
digital watermark information is embedded;

instructing the computer to detect a function embedded in the target content;

instructing the computer to generate, based on the key information, an ordering function ~~by mapping from a first randomized space to a second randomized space, the first randomized space and the second randomized space including a target space concerning embedding amounts;~~

instructing the computer to map each block of the acquired target content with embedded digital watermark information to a randomized space comprising embedding amounts;

instructing the computer to compute a composite function ~~by composition of~~ based on the ordering function and the embedded function; and

instructing the computer to compute a topological invariant based on the composite function, ~~[[and]]~~ the topological invariant serving as digital watermark information,

wherein the ~~ordering function is generated and the composite function is computed to obtain an~~ embedded target content ~~[[being]]~~ is restored to ~~[[an]]~~ original target content even if the embedded target content ~~[[is]]~~ was subjected to geometrical distortion ~~after the digital watermark information is embedded in the target content.~~